NORTHUMBERLAND

SEA FISHERIES' COMMITTEE.

1898.

Report on the Trawling Excursions

CARRIED ON

DURING THE SUMMER OF 1898,

AND ON OTHER

Scientific Work done in connection with the Marine Laboratory at Cullercoats

BY

ALEXANDER MEEK, M.Sc., F.Z.S.,

THE DURHAM COLLEGE OF SCIENCE, NEWCASTLE-UPON-TYNE.

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Printed by order of the Committee, 20th October, 1898.

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Newcastle-on-Tyne:

CAIL & SONS, 29 AND 31, QUAYSIDE.

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CONTENTS.

	PAGE
Trawling Excursions	3
With a Deep-Sea Trawler to the Fishing Grounds off Fair Isle	19
On the Hatching of the Waste Ova of the Markets ...	25
On the Crab	28
The Marine Laboratory	31
Mussel Culture in Northumberland	33

THE TRAWLING EXCURSIONS.

What might be termed our annual stock-taking of the sandy bays along the coast has been once more completed. The constant character of the excursions, the similar conditions of time and season and apparatus make the statistics now at our disposal of the greatest value. And I beg, therefore, to take this early opportunity in my report to record our grateful thanks to Mr. John Dent for the use of the steamer "Livingstone," and also to him and others who accompany us, as well as the crew, for much help in making the observations.

These trawling experiments have been made annually for seven years, and the purpose of them, as you well know, was primarily to test the value of the 3-mile restriction to trawlers,—a restriction which came into force the year before the experiments were begun. It is regrettable that we have no comparative statistics of the yields of these bays in years prior to the adoption of the in-shore restrictions, and before trawling began to deplete them. What we do know, and it seems fairly reliable, so far as memory can be reliable, I gave in the first report I had the honour to present to you—that for 1896. It tended to show that the in-shore waters, and, inferentially, the deeper waters as well, were much richer in the most valuable flat fishes in the pre steam-trawling days. With the great and marked increase in the improved method of catching fish, the imports and the value of fish landed rose rapidly every year. The area fished grew more and more extensive, until in these days not only the whole of the North Sea, but the North and West of Scotland and even Iceland are visited to aid in swelling our statistics. It is a consideration of this which forces many of us, scientific or not, to ask—is there a danger of over-fishing? It is believed that the increase in the catch is not at all commensurate with the high development in the means of fishing, the immense area now almost constantly worked upon, and the great increase in the number of boats and men. Still the steamers are being multiplied, and more men and more money are being enticed into the industry, and the trawlers at any rate are more than able to make it pay. Trawlers

as a rule do not complain of the scarcity of the fish. With the improved boats and gear at their command, they are able to go great distances, and from place to place if necessary, until they get a "voyage" worth bringing into market. It is the line fishermen, compelled to more restricted work from their smaller boats, and the use of apparatus which is not subject to much improvement, nor is or ever will be capable of gaining immense catches, who find most reason to grumble. They have seen how easily they can eradicate mussel beds, and seriously reduce the crab and lobster fisheries. They find that not only is the steam trawler with his immense catches a serious competitor in the market, but at sea there are signs that the near fishing grounds are not yielding them the catches they used to get, that, in fact, the ordinary fisheries are being reduced likewise. It was said at first that the trawlers were the cause of this presumed reduction by destroying the ova, the young and the food of the fishes, and it was confidently hoped that the closing of the in-shore waters to trawlers would reserve and protect the fish from such destruction, besides providing ample fishing for the line fishermen. But the fact to which I have in previous reports drawn your attention is that such a distinct increase has not occurred, neither here nor in Scotland, where much more elaborate and similar experiments have been made. This being the case, and as, moreover, trawling has been proved to be much less destructive in these respects than was supposed, we are compelled to say, with the advisers of the Scottish Fishery Board, that it is because there is a general over-fishing. The numbers are not surprisingly different year after year, and it is therefore possible that we have reached a limit, below which over-fishing cannot influence at least the in-shore fisheries so very much. Nevertheless, we can easily imagine at the time, not so long ago, when the North Sea as a whole was not fished to any large extent, that these bays and the in-shore waters would participate in the general richness, that now the smallness of the numbers obtained in one area is but expressive of the condition of the whole.

With these observations I now beg to draw your attention to this year's results.

TABLE 1.—Shewing the number of fish obtained at each of the excursions.

PLACE.	DATE.	Turbot.	Brill	Sole.	Plaice.	Dab.	Flounder.	Whiting.	Codling.	Mackerel.	Gurnard.	Skate.	TOTAL.	Mid-day Temp. of Surface.	SEA.	WIND.
														Degrees F.		
Skate Roads ...	June 23rd, 1898.	23	5	1	95	39	6	...	...	...	6	3	178	50	Smooth.	W.N.W.
Druridge Bay ...	,, 30th ...	7	1	3	105	91	1	...	...	...	16	3	227	51·5	Do.	N.E., rain in the morning.
Alnmouth Bay ..	July 6th ...	11	...	3	117	59	18	2	...	...	19	1	230	52	Do.	W.N.W., stiff breeze.
Blyth Bay	,, 13th ...	1	...	11	103	67	1	...	9	...	7	...	199	53	Rough.	N.E.
Druridge Bay ...	,, 20th ...	11	2	6	70	150	3	...	...	...	43	3	288	55	Slight.	S.E.
Alnmouth Bay ...	,, 27th ...	9	2	...	195	113	5	...	...	...	11	...	335	55	Smooth.	N.W., strong.
Skate Roads ...	Aug. 1st ...	7	1	2	154	16	7	...	...	...	...	...	187	55	Do.	Do. do.
Cambois Bay ...	,, 10th ...	2	...	7	56	82	1	...	...	...	13	...	161	55	Moderate.	S.W.
Goswick Sands ...	,, 22nd ...	19	7	1	474	29	7	...	...	...	42	7	586	55	Smooth.	S.
Druridge Bay ..	,, 31st ...	8	...	3	83	72	2	...	...	...	12	6	186	53·5	Rough.	N.E., changing to W.
Goswick Sands ...	Sept. 5th ...	14	7	5	458	47	21	...	...	2	52	3	609	56·5	Smooth.	Calm.
	TOTALS	112	25	42	1,910	765	72	2	9	2	221	26	3,186			
	Average per Day ...	10	2	4	174	70	7	·2	·8	·2	20	2	290	54		

At Skate Roads on June 23rd a good deal of weed was gathered up by the trawl at most of the hauls, much of it evidently coming from Budle Bay. Among the fish, many anglers of some 12 inches occurred.

The trawling was very clean at Alnmouth Bay on July 6th.

Our excursion to Blyth Bay on July 13th was rendered difficult on account of the swell produced by a stiff N.E. breeze, and we found that we could only trawl with comfort one way along the bay. We started at 9 a.m., trawled in this manner until 12 o'clock, at which time we ran in for luncheon. Another hour was given to the bay in the afternoon. We had thus four hours' trawling.

At Cambois Bay on August 10th we trawled for about seven hours, which is shorter by nearly three hours than in previous years.

On August 3rd, when we visited Druridge Bay, there was a very strong gale from the S.W., changing in the morning to N.W., and consequently a strong sea was running in. It gradually got quieter, however, and towards evening the sea was almost calm. The fishing was poor in the early part of the day, but improved later. Five hauls were made.

An important departure was made this season in that we made two visits to Goswick Sands, to the results of which I shall refer after dealing with the bay previously visited.

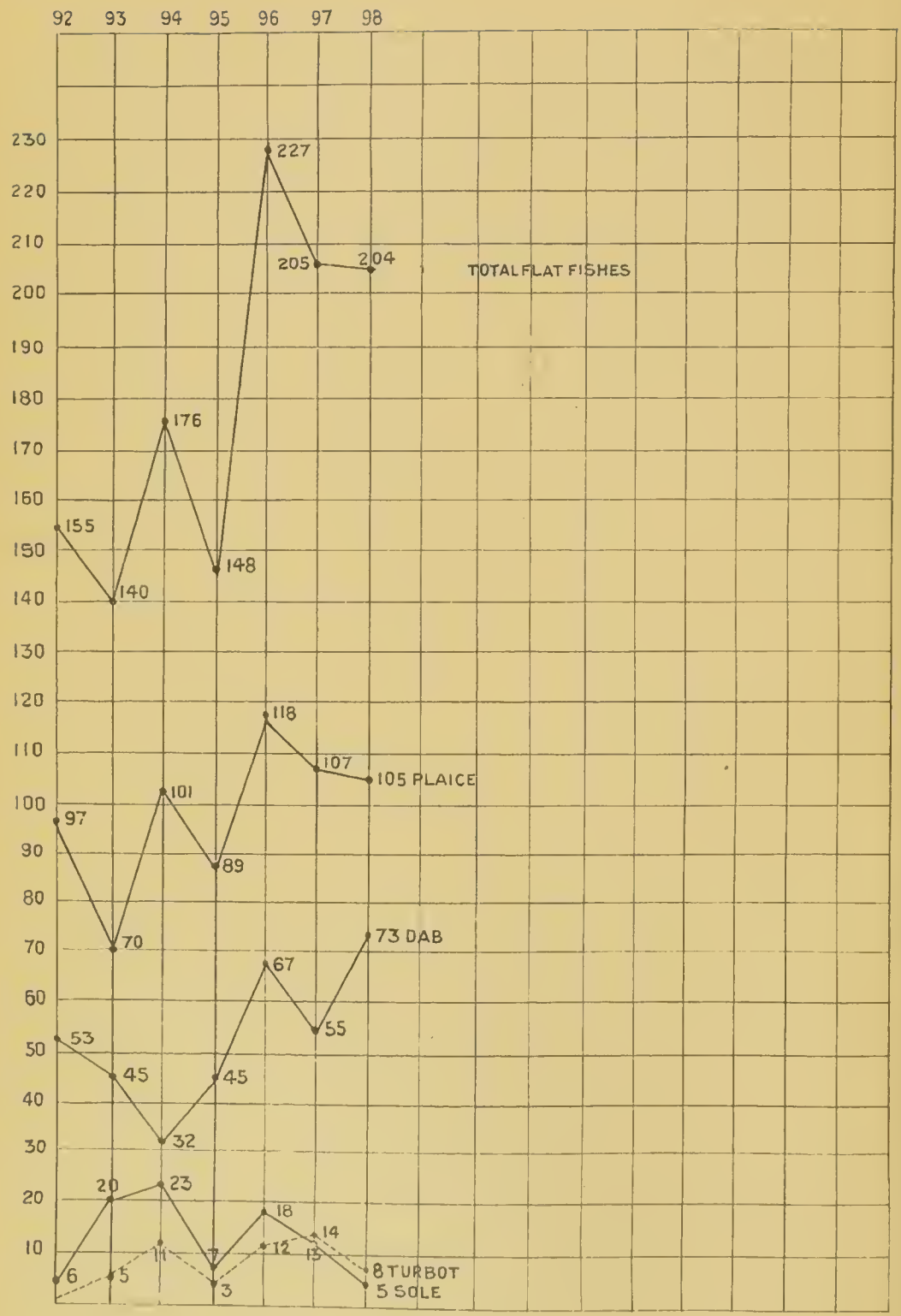
A glance over the complete tables given in the last report will show that slight changes have occurred, usually in the way of a decrease from last year's results. The improvement in plaice and dabs is continued in Blyth Bay. In Cambois Bay, an all-round decrease has to be reported. Druridge Bay presents a decrease in plaice—in quality as well as in quantity, but it gives an increase in dabs. There is practically no change in Ahnmouth Bay. Skate Roads gives a decrease in turbot and plaice.

The total numbers of flat fishes obtained this year for each bay are as follows:—

Blyth Bay ...	July 13 ...	...	183 (4 hours).
Cambois Bay ...	Aug. 10 ...	...	148 (7 hours).
Druridge Bay ...	June 30 ...	...	208
Do. ...	July 20 ...	...	242
Do. ...	Aug. 31 ...	...	168
	Average	...	206
Ahnmouth Bay ..	July 6 ...	...	208
Do. ...	,, 27 ...	...	324
	Average	...	266
Skate Roads ...	June 23 ...	...	169
Do. ...	Aug. 1 ...	...	187
	Average	...	178

The total catch of flat fishes for the year therefore is 1,837, which gives an average of 204 for each day, a result almost identical with that of last year. The returns for each bay, however, present many divergencies. In Blyth Bay, an increase in flat fishes can still be demonstrated. Ahnmouth Bay may be said to be steady. Cambois Bay shews a decrease, and Druridge Bay and Skate Roads have markedly decreased.

The graphic representation herewith will bring home to the readers of this report the results for the seven years. It will be seen that the catch of flat fishes for all the bays shows still the gratifying result that the increase of the two previous years is still being kept up. "Curves" are added which present, in a similar manner, the returns for the more important species. These have been made from the following figures:—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227
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204
TOTAL FLAT FISHES
176
155
140
148
118
107
105 PLAICE
101
97
89
73 DAB
70
67
55
53
45
45
32
20
23
18
14
12
13
11
7
6
5
3
8 TURBOT
5 SOLE

TURBOT.

Year.	Blyth B.	Cambois.	Druridge.	Alnmouth.	Skate Rds.	Aver.
1892	·7	1·7	—	—	—	1
1893	4·5	3	8	6	—	5
1894	2	1	17	13	23	11
1895	2·5	3	4	5	2·5	3
1896	1·5	8	10	11	28·5	12
1897	2	2·5	20·5	7	38·5	14
1898	1	2	8·7	10	15	8

SOLE.

1892	1·3	5	13	—	—	6
1893	36·5	9·5	26	9·5	—	20
1894	43	39·5	20·5	10·3	1	23
1895	16	4	9·7	5·5	1·5	7
1896	20·5	24	23·3	19·5	3·5	18
1897	3	23·5	26	6	5·5	13
1898	11	7	4	1·5	1·5	5

PLAICE.

1892	56	93·7	140	—	—	97
1893	48	55	80	95·5	—	70
1894	67	24	98	85·3	230·5	101
1895	61	51	122·7	109·5	97·5	89
1896	74	76	140·3	178	120	118
1897	55	83	115·5	155·5	124·5	107
1898	103	56	86	156	124·5	105

DABS.

1892	31	57	70	—	—	53
1893	21	31·5	53	74·5	—	45
1894	23	14·5	47	49·7	26	32
1895	63·5	23	48·3	61	27·5	45
1896	61	81	86·3	80·5	27	67
1897	35	93	69	52·5	25	55
1898	67	82	104·3	86	27·5	73

The total increase in the flat fishes is thus seen to be mainly due to an increase in dabs and plaice, which species form together the large proportion of our catches.

The more migratory round fish and the other flat fish are so inconstant or so meagre in numbers that it is impossible to represent them in the above manner. The haddocks and whitings for example, which were got often in large numbers in previous years, have practically disappeared in the last three years from the places in which we trawl.

The reader on referring to Table I. will note the striking figures obtained for plaice at our two excursions to Goswick Sands. These sands lie to the north of Holy Island, and afford a considerable stretch of good fishing ground, though the rough ground at each end, and outside in some six fathoms at the north end, must be carefully remembered as we have good reason to know.

On the 12th August we made five hauls between 8 a.m. and 3 p.m., with the results given in the Table. The 586 fish was made up principally of plaice, of which 474 were obtained. The immature fish, as will be seen from page 12, also consisted largely of plaice. This is a result which was only approached to in 1894, when we got 371 plaice in Skate Roads, the bay to the south of Holy Island. There was evidence of plenty of food for these fishes being present. Great shoals of sand eels could be seen almost at any time during the day, and we found that the majority of the flat fishes were feeding upon them. The sand eels attracted also a large number of terns, cormorants and gannets.

It is quite possible that the large proportion of plaice may be to some extent explained from the operations of the Dunbar hatchery. The hatchery was established in 1894, and as in the early years the whole of the fry was deposited in the Firth of Forth and St. Andrew's Bay, it would be surprising if the fish caught in such a likely place as Goswick Sands did not include some of those artificially hatched at Dunbar. This becomes more probable if we consider the results of the experiments on currents conducted by Dr. Fulton for the Scottish Fishery Board. Dr. Fulton kindly wrote me on Oct. 10th: "I find that in 1894 and 1895 we put into the Firth of Forth, St. Andrew's Bay, and off Dunbar about 64,000,000 plaice fry. From the set of the currents on the coast, I should expect your area to benefit as much as ours."

It is thus more than probable that the large takes in plaice at Goswick Sands are made up of many of the survivors of the fry placed in the Forth off Dunbar in 1894-5 and even later.

This would not explain, however, the large catch of plaice obtained at Skate Roads in 1894. But there is this difference between the two cases. At Skate Roads the numbers were not kept up at the second visit that year, after an interval of forty days; nor in the following years. At Goswick Sands, our second visit on Sept. 5th, at an interval of a fortnight, resulted in a very similar catch to the first: there were 458 plaice in a total of 609.

It would be premature to speculate on these results until we see what another season's visit to the grounds discloses. The results of this year will be hard to beat, and we shall therefore look forward with much interest to a future trial at Goswick Sands. But, in this connection, it is interesting to note that the district as a whole has improved in flat fishes, especially in plaice and dabs, since these experiments were commenced. This improvement has been more marked in the last three or four years, and thus we are in a position to say that the closing of these in-shore waters to trawlers has resulted in a benefit to the district. On the other hand, the most valuable flat fishes—the turbots and soles—are, I am sorry to say, seeming to decrease in numbers, which are never large, every year.

The *Fish retained*, as in previous years, consisted for the most part of plaice and dabs, and of these the plaice have practically always occupied the premier position. But occasionally the figures in a single day's fishing present a larger proportion of dabs. This is the case for instance this year at Druridge Bay, when we recorded 150 dabs and only 70 plaice.

Last year I drew attention to the size of the plaice. In many of the bays the plaice were often what might be called deep-sea fish. Such large fish this season were just as conspicuous by their absence. It was only at Skate Roads and at Druridge Bay, in the early part of the summer, that fairly large plaice were obtained, and again at Goswick Sands the plaice were medium in size, though not all those retained were mature. The season as a whole did not furnish, however, such sizes as were recorded last year. This will be evident in the notes on the sizes on page 14.

The dabs on the other hand this year were very often excellent large fish.

The bays continue to furnish good turbot and soles, though in declining numbers.

THE MATURE v. THE IMMATURE FISH.

Following out the plan begun in 1896, and continued last year, an attempt was made to indicate the proportion between the fish retained and those returned to the water. To avoid complications, it was decided last year that this determination should be made if possible at the first haul. And this course was successfully pursued in all cases except one, when, through an accident to the gear twice in succession, the counting was postponed until the third haul. The results are presented in the following tables :—

TABLE II.—Shewing the Mature and Immature Fish at the first haul in each bay.

Skate Roads.

Fish.	June 23rd.		August 1st.		General Observations.
	Mature	Immature	Mature	Immature	
Turbot ...	2	...	1	...	June 23rd.—One or two young turbot were got in succeeding hauls, and the immature seemed then to increase in number.
Brill ...	3	...	...	1	
Sole ...	...	...	1	...	
Plaice ...	18	18	59	89	Aug. 1st.—The successive hauls were very similar.
Dab ...	4	1	8	6	
Flounder	5	1	1	...	
Angler ...	...	...	...	23	
	32	20	70	119	

Druridge Bay.

Fish.	June 30th.		July 20th.		August 31st.		General Observations.
	Mature	Immature	Mature	Immature	Mature	Immature	
Turbot ...	1	...	2	...	1	...	June 30.—The nature given is the average of the 5 hauls. In all other cases they were counted.
Brill ...	...	...	1	...	...	...	
Sole ...	1	...	1	...	3	...	July 20th.—Good numbers of small dabs and plaice at succeeding hauls, with gurnard and one or flounders. The dabs were always most numerous.
Plaice ...	21	18	8	19	29	23	
Dab ...	18	20	40	49	18	12	
Flounder	...	...	...	3	1	...	Aug. 31st.—Somewhat the same proportion at subsequent hauls. A small whiting at fourth haul. A few small anglers each time.
Gurnard.	3	16	6	5	1	...	
Angler ...	...	...	1	4	...	1	
	44	54	59	80	53	36	

Alnmouth Bay.

Fish.	July 6th.		July 27th.		General Observations.
	Mature	Immature	Mature	Immature	
Turbot ...	2	...	3	...	July 6th. — Succeeding hauls shewed also a large proportion of immature. The mature plaice were not very large in the early part of the day, but at night, after high tide, there was a good catch of fairly large plaice.
Brill ...	...	...	...	...	
Sole ...	...	1	...	...	
Plaice .	24	53	19	56	
Dab ...	14	29	28	34	July 27th.—Large numbers of immature fish at every haul. One immature Lemon Dab in the afternoon.
Flounder	9	31	2	22	
Gurnard.	6	5	...	17	
Angler ..	...	4	..	2	
	55	123	82	131	

Blyth Bay. Cambois Bay.

Fish.	July 13th.		August 10th		General Observations.
	Mature	Immature	Mature	Immature	
Turbot ...	1	...	...	...	Blyth Bay, July 13th.—A good many immature dabs and plaice, with a few small anglers at every haul. One or two small soles were observed likewise, and this was also the case in Cambois Bay.
Brill ...	...	...	...	...	
Sole ...	...	...	1	...	
Plaice ..	21	20	6	20	
Dab ...	10	6	8	14	
Flounder	...	...	1	1	
Gurnard.	1	8	...	4	
Angler ...	...	...	2	2	
	33	34	18	41	

Goswick Sands.

Fish.	August 22nd.		September 5th.		General Observations.
	Mature	Immature	Mature	Immature	
Turbot ...	3	3	2	...	Aug. 22nd.—A large number of anglers at every haul—all small—not exceeding 12-15 inches. There were some 50 at the fourth haul. The immature fish presented a large majority of plaice.
Brill ...	2	...	...	1	
Sole ...	...	...	...	...	
Plaice ...	156	105	82	140	
Dab ...	12	17	14	2	Sept. 5th.—This is a record for the third haul. The large majority of plaice was again very apparent in the other hauls. Among the small fish were two or three turbot and one brill, also brill of 8—10 inches.
Flounder	...	...	1	3	
Gurnard .	9	21	...	...	
Angler ...	...	28	...	4	
	182	174	99	150	

The two previous years gave the interesting but disappointing results that the plaice were not so numerous in the young condition as in the adult, while dabs and flounders were as a rule more numerous in the young condition. This year's records show a much more pleasing proportion of young plaice, while at the same time they indicate that the coast is liable to great fluctuation in this respect.

It is seldom that we meet with small turbot or brill, or even soles. Young flounders this year seemed very scarce. And as regards the plaice and dabs, sometimes the mature were in the majority, sometimes the immature, but the numbers in each class follow one another quite remarkably. If there is a good catch of keepable fish, a similar quantity has to be returned to the sea. If there is a bad catch, a similarly small number has to be rejected. Thus it seems that the conditions of life, which at this time of the year is altogether a question of feeding and the avoiding of enemies, influence both classes much alike.

The question is important enough to justify us bringing the records for last year together, so that they may be contrasted with those given above.

PLAICE, 1897.

	Druridge.	Alnmouth.	Blyth.	Cambois.	Total.	%
Mature	106	80	15	27	228	100
Immature	81	66	22	39	211	93

PLAICE, 1898.

	Skate Roads.	Druridge.	Alnmouth.	Blyth.	Cambois	Goswick	Total.	%
Mature	77	58	73	21	6	238	473	100
Immature	107	60	109	20	20	245	561	119

DABS, 1897.

	Druridge.	Alnmouth.	Blyth.	Cambois.	Total.	%
Mature	43	28	10	17	98	100
Immature	72	39	22	53	186	200

DABS, 1898.

	Skate Roads.	Druridge.	Alnmouth.	Blyth.	Cambois.	Goswick.	Total.	%
Mature	12	76	42	10	8	26	174	100
Immature	7	81	63	6	11	19	190	109

GURNARDS, 1897.

	Druridge.	Alnmouth.	Blyth.	Cambois.	Total.	%
Mature	18	28	5	11	62	100
Immature	105	155	7	32	299	482

GURNARDS, 1898.

	Skate Roads.	Druridge.	Alnmouth.	Blyth.	Cambois.	Goswick.	Total.	%
Mature	—	10	6	1	—	26	43	100
Immature	—	21	22	8	4	19	71	172

FLOUNDERS, 1897.

	Druridge.	Alnmouth.	Blyth.	Cambois.	Total.	%
Mature	2	5	—	3	10	100
Immature	1	31	15	3	53	530

FLOUNDERS, 1898.

	Skate Roads.	Druridge.	Alnmouth.	Blyth.	Cambois.	Goswick.	Total.	%
Mature	6	1	11	—	1	1	20	100
Immature	1	3	53	—	1	3	61	305

It is not pretended, of course, that these numbers show a rigorous contrast between the mature and the immature fish; and when these terms are used as above it must be understood that they simply refer to the fish retained and the fish rejected. The latter are altogether immature, certainly; the former include a fair number of immature likewise, but immature which are, so to speak,

nearly of mature size. And as the same method of counting will be adopted in subsequent seasons, the numbers will be of considerable interest and importance.

A great variation occurs, but the results bear one another out in some respects. For 1896, the plaice, so far as they were counted, were about 100 mature to 75 immature; the gurnards, 100 mature to 240 immature; and a large proportion of flounders was shown likewise in the immature condition. Thus these observations agree with those of the two subsequent years with regard to gurnards and flounders, and for 1897 with regard to place. This year the plaice are represented in larger numbers of the smaller sizes, while in the other forms the immature are not so numerous as in the previous seasons. To give more point to these results I purpose counting and measuring the whole of the first haul next season, because, for one reason, the above contrast between the plaice and the dabs is bound to be an unequal one.

THE SIZE, FOOD AND SEX OF THE FISHES.

As in previous seasons, examples of each class of fish were examined and measured.

Turbot.—Thirty-one were measured, the largest being those got at Druridge Bay on July 20th, some of the measurements being 25½ in. × 20 in., 21½ in. × 16 in., 21 in. × 16½ in., 18¼ in. × 14 in., 18 in. × 14 in. They varied at the other places from 12 in. × 9 in. to the numbers just given. Among nineteen of these, seven were empty, five were feeding on sand eels, three on whitings, two on weevers, one on sand eels and whiting, and one on weever and sand eels. There were eight males and eleven females. In 1897, among fourteen, there were six males and eight females.

Brill.—Eleven were measured, varying from 10½ in. × 6¾ in. to 17 in. × 11¼ in. Among nine, one was empty, six were feeding on sand eels and two on whitings. There were three males and six females.

Flounder.—Thirteen gave measurements from 9 in. × 5½ in. to 17 in. × 9 in. Among eleven, five were empty, two were feeding on sand eels, one on whitings, one on *Tellina tenuis*, one on *Loligo marmoræ* and *Portunus holsatus*, and one on young mytilus. There were one male and ten females.

Plaice.—Among the thirty-eight measured there were only three which were 20 inches and over, these measuring 20 in. × 12 in., 26½ in. × 15 in., and 26¼ in. × 15½ in. The majority varied from

about 12 in. to 18 in. Among twenty-nine of these, nine were empty, five were feeding on sand eels, seven on *Tellina tenuis*, three on *Donax trunculus*, two on annelids, one on young sand eels and annelids, one on young mytilus, and one on *Tellina tenuis* and a grain of maize! Of twenty-six, there were eleven males and fifteen females. In 1897, among twenty-two plaice, there were nine males and thirteen females.

Dab.—Thirty-three were found to vary from 8¾ in. × 4½ in. to 13½ in. × 7¾ in. At Ahmouth, on the 27th July, one measured 16¼ in. × 9 in., and at Goswick Sands dabs were got measuring 13¾ in. × 8 in. and 13¼ in. × 7¼ in., which numbers were approached to in most of the bays. Among twenty-nine, five were empty, seven were feeding on sand eels, seven on *Portunus holsatus*, four on *Eupagurus bernhardus* (all at Ahmouth Bay on 27th July), one on *Tellina tenuis*, one on *Tellina tenuis* and young mytilus, one on sand eels and *Portunus holsatus*, one on *P. holsatus* and solen, one on amphipods, among which were broken molluscan shells, and one had a much digested fish—probably sand eel. Among twenty-eight dabs, there were two males and twenty-six females. In 1897, among eighteen, there were three males and fifteen females.

Sole.—Ten were measured, varying from 10 in. × 4 in. to 19 in. × 8½ in. Of seven of these, six were empty, one was feeding on sand eel. Among nine of them, two were males and seven females. In 1897, among sixteen, there were two males and fourteen females.

The Codling got in Blyth Bay on July 13th were feeding on *Portunus holsatus*, weever, and *Loligo marmorae*.

The Cole Fish was feeding on *P. holsatus*.

The Skate (*Raia circularis*) were feeding in one case on sand eels, in another on solen, usually on *P. holsatus*.

The Gurnards shew a similar majority in the favour of the females. In 1897, among fifteen gurnards, there were one male and fourteen females.

This disproportion between the numbers of the sexes is not at all uncommon in the animal kingdom. Here it is associated with a total absence of secondary sexual characters even at the spawning season, of intercourse between the sexes, and also of parental care. The dragonet appears to be the only fish with floating ova in which sexual colouration occurs. But in this case an intimate relation between the sexes takes place at the spawning season, a habit first described by Saville Kent, and this year made the subject of an

admirable paper by Holt. It appears from Fulton's observations, however, that a large proportion of females is likewise found among the dragonets.

My notes on the subject of the relative numbers of each sex are as yet too fragmentary to be beyond reproach, but they are on the whole confirmatory of those made some years ago by Dr. Fulton. At the time that they were made in my case, it might be supposed that, as spawning as a rule was not taking place then, a redistribution of the sexes would occur. This is not at all likely, however, and besides, the greatest disproportion was shewn in the case of the dab and gurnard, which spawn to some extent in-shore, and during part of the time in which the observations were made.

It is quite surprising, when we consider the conspicuous polygamy amongst our common and most valuable fishes, and the large number of floating ova which the females shed, that an unfertilized egg is a rarity we are more likely to hear about than to see. A detailed examination of a large number of forms at different times of the year would yield very interesting comparative figures, which would tend to help in explaining the condition.

The fish found in an abnormal condition included several diseased forms, but as usual a large number of the flat fishes were observed pigmented more or less on the blind side. The fact that this is usually altogether without symmetry goes to shew that it is the result of irritation, and not a persistent larval colouration.

A flounder got at Skate Roads at the first excursion was spotted all over on the white side, and including the fins, with small brown spots, scattered in quite an asymmetrical manner. Pigment is exceedingly common on the blind side of turbot and brill caught here and elsewhere. Plaice are got at almost every catch with isolated spots of brown pigment. At Blyth Bay, for example, one plaice showed this colouration on the blind side in the form of irregular blotches of a golden yellowish brown hue. There was not the least approach to symmetry in this and many other specimens presenting more or less of blotches or spots on the blind side. A flounder was observed on that day likewise with three spots, all on the ventral aspect of the blind side, and another with one spot near the middle line.

The other specimens got in the trawl and tow nets I do not propose to enumerate here. They will in due course be entered in the lists we are preparing of the occurrence and distribution of species.

PELAGIC OVA.

These were not at all numerous at our ordinary excursions. The following gives a general resumé of the results :—

Skate Roads, June 30.

Surface.

Weever	...	...	numerous.
Gurnard	...	...	a few.

One egg which measured 1·395, with no oil globule, distinct perivitelline space, homogeneous yolk, pigment not yet well developed, but evidently black and branched, may be that of the lemon dab.

Druridge Bay, June 30th.

Surface.

Weever	...	...	some	12.
Dab ...	...	...	...	1.
Rockling	...	...	about	6.
Gurnard	...	..	...	1.

There were no eggs in the mid-water net.

Ahmouth Bay, July 6th.

Surface.

Dab ...	...	...	a few.
Gurnard	...	...	do.

Blyth Bay, July 13th.

Surface.

Weever	...	...	a few.

Mid-water.—No ova.

There was a heavy swell.

Druridge Bay, July 20th.

Surface.

Weever	...	...	a few.
Rockling	...	...	do.

Mid-water.

Weever	...	...	... 1.

Alnmouth Bay, July 27th.
Surface.
Gurnard ... ... a few.
Dab ... ... do.
Mid-water.—Same as Surface.
After this date, no pelagic ova were obtained.

But if during the summer the pelagic ova did not occur in any quantity, a few trials with the surface net earlier in the year yielded numerous ova of great interest.

Our first trial was on the 30th December, 1897. There was a heavy swell. We got no ova in the surface net, the catch being composed almost entirely of sagitta.

In response to a letter I sent to the skipper of the "Livingstone," I received the products brought in with a surface net on the 30th March, with a note that the net was towed from Blyth harbour mouth S.E. across the bay for about three miles and back again. For a few days before there had been a heavy easterly wind and sea, and I was therefore not surprised to find a large number of eggs, including the following important forms:—

Cod, some 20. In most cases the embryos were already well advanced when examined on the 1st April. They were set aside in a small jar to hatch, and the free embryos were found swimming about in the jar when examined again on the 6th April, but they died by the 13th.

Whiting, about 15. These were hatched likewise in small jars.

Motella mustela, numerous.

Several eggs measuring ·992, with transparent homogeneous yolk, pigment in black isolated spots along the dorsal and middle aspect of the tail, the dorsal line extending to the head, the mid-ventral one passing on to the side of the body, without an oil globule, I take to be those of the poor cod (*Gadus minutus*).

Again, on the 13th April, through the kindness of the skipper of the "Livingstone," we received the tow-netting products obtained on the previous day. The steamer was going at the time from about ten fathoms off Newbiggin south as far as opposite Cambois Pit.

There were fewer eggs, but they included as before many *Motella mustela*.

One egg measuring 2·09, without an oil globule, with the egg membrane yellowish in colour, with yellow pigment on the embryo generally distributed but not intense, with a large perivitelline space, appears to be that o fthe long rough dab (*Hippoglossoides limandoides*).

WITH A DEEP-SEA TRAWLER TO THE FISHING GROUNDS OFF FAIR ISLE.

Through the favour of an introduction from Mr. W. H. Storey, of North Shields, to Messrs. R. Irvin & Sons, of Shields and Aberdeen, I was able to conclude this year's trawling excursions with a voyage in a deep-sea trawler. I was anxious for one thing to see the ordinary life of the crew, and the nature of the fishing. I was also desirous of adding to our collections by the use of a surface net, and by gathering amongst the material brought up in the trawl. I wished, moreover, to compare an ordinary deep-sea trawling voyage with our experimental efforts on this coast.

For the purpose of collecting I took with me three boxes, with bottles and preserving re-agents, and a surface net similar to the ones we use at our excursions.

The "Ben Ledi" is one of the newest boats belonging to the Messrs. Irvin, and like all the modern boats it is fitted with otter trawls capable of over 100 feet extension between the boards. The trawling is done at half-speed, and in this case the gear had to pass over so many pulleys that one never knew how the net was faring, whether it was torn or safe. But the arrangement was a great saving of manual labour, practically everything being done by steam. The light necessary for hauling in and sorting the fish at night was supplied by acetylene lamps placed one on each side of the wheel-house.

We started from Aberdeen on the afternoon of Friday, 9th Sept. The log was duly launched as we passed Buchan Ness, and next morning it registered 145 when we got near to Fair Isle. This was about 8·30, and as soon as we got the island bearing in the right direction we started fishing in 55—57 fathoms. There was a heavy swell, and the weather looked quite unsettled. The result of the fishing was fairly good catches of large plaice, with megrims and lemon dabs, along with haddock and cod, hake and ling. But there were so many "splits" in the process that the work of mending the nets finally became too irksome. Another boat, the "Mizpah," followed us to this ground on the Saturday, and was similarly unfortunate. The cause of the trouble was quite apparent

when we brought on board a large boulder, and it seemed that we got among quite a number of them. The skipper told me that on the previous occasion he had never had a "split" on this ground, which he seemed to know very well, so that the stones seem to be exposed and covered by the strong currents of that region shifting the sand. We kept on at this ground, however, until Monday, when the skipper decided that he had had enough of it,—not of fish, but "splits,"—and he now directed the boat to off Sumbrough Head. The lead disclosed again a good fishing ground of coarse sand in 64—65 fathoms. The "dan" was set down, and the fishing commenced once more. One haul, however, was quite sufficient. There were fish, but the cod end contained besides a larger boulder than the first one, and which tore the net so severely that it was not completely mended again during the voyage. I was pretty sure some of the crew were looking upon me now in the light of a bringer of ill-luck. We had got by this time perhaps about £50 worth of fish on board, which would not be a paying catch at all. The skipper elected to change the ground again, and try what could be done in the deeper water off Fair Isle. We accordingly went back to W.N.W. of the island, and began fishing late on Monday night in 72—75 fathoms. To make things somewhat worse, the night promised to be a wet one. But in the morning it rapidly cleared up into a fine day. On this day, Tuesday, I took the temperature of the surface water and found it to be 51° F. at 9·45 a.m. The air at 10·45 a.m. was 54° F., at 3 p.m. 58° F. and became cooler again at night.

I found in the morning that they had been catching a fair number of fish, and fortunately were keeping free of "splits." We were now using the starboard gear, and as the day went on we got bigger and bigger catches, which consisted first of a large quantity of cod, and then, just as the skipper desired, without the cod decreasing in number, an immense quantity of haddocks was added to the catch. The first catch of cod was about as much as could be lifted on board, but after about a four hours' drag—the common time given—the second haul, when we struck what we might call this Klondyke of fishes, there were so many in the net that the crew dared not bring it in. The cod end was brought alongside and fixed, and the skipper slit the net open and with the aid of his men began to bale it out with a basket. Even when it was so lightened of its load that the cod end could be brought on board, the net could not

be untied in the usual way, and again a slit had to be made to liberate the fish. The ponds on deck were already pretty full, though the cod had been thrown into the hold, and as the fish ran out of the net they completed the filling of the ponds, reaching almost up to the top of the bulwarks, and escaping over the ponds they formed a living, seething, struggling mass on each side of the wheel-house. I never saw so many fish caught at once before. We had now to stop fishing for a couple of hours or so to gut the haddocks and clear the way a bit for the next haul. These had, moreover, to be made of shorter duration, and as night was drawing on it was a serious matter for the men. The short watches were all taken up in gutting and cleaning the haddocks, consequently they were working the whole night. The night's fishing, however, was so successful that in the morning the skipper decided on running into market. This was Wednesday, and we arrived in Aberdeen just before eleven that night.

I went down to see the fish sold the next morning, and through the kindness of the Messrs. Irvin I am enabled to present the following account of the catch :—

Turbot			10
Hake...			152
Ling			77
Cod			1,140
	Cwts. or Boxes.		
Lemons ...	... 1	... ...	90
Medium Plaice	... $8\frac{3}{4}$ × 45...	...	394
Large do.	... 2 × 21...	...	42
Megrims ...	... $3\frac{1}{4}$ × 55 ..	...	180
Large Haddocks	...143 × 90...	...	12,870
Medium do.	... 12 × 160...	...	1,920
Codlings ...	... 10 × 110...	...	1,100
			17,975

The price the catch sold at was £115, and thus the voyage which threatened so badly at the beginning turned out to be a very profitable one indeed. The "Ben Ledi" completed another voyage to the same place before I left Aberdeen, and the fish were sold for £160. The favourable conditions for fish and fisher were evidently then continuing. In regard to the catch I have just enumerated, I have added approximate numbers per box for each

class of fish, kindly got for me by Mr. John H. Irvin, Aberdeen, and this enables me to say that the fish caught, in round numbers, amounted to about 18,000.

This is an immense number of fish to be caught by one boat at a single haul. It is not a record catch either, though much above the average, and when we consider the large number of boats fishing from all the ports along the east coast it must be seen that heavy inroads into the number of food fishes inhabiting the North Sea are made. Still the trawler, unless an accident happens to his boat or his gear, can always bring enough fish into market to leave a respectable margin after paying expenses. He tries here and there if he finds that the fish are no longer in the place where he was getting them in plenty at a previous occasion until he finds such another place.

Off Fair Isle, where we were fishing, is practically virgin ground. It is not often visited by trawlers, and not by many at a time. In that particular area where we struck the fish there were what might be called shoals, or one great shoal of haddock and cod. They were attracted there by spawning herring, for the latter were feeding for the most part on herring and the former on herring spawn. That the several classes do not mingle to a large extent was shown in comparing a catch of the "Mizpah's" with one made at the same time by the "Ben Ledi." We had just got our first large catch of cod and haddock. The "Mizpah," fishing a little farther out, got scarcely anything but cole-fish, or as the skipper of that boat put it—"as many blackjack as I could bring in and throw overboard again."

The cole-fish, skate, and dog-fish were all rejected, and some of the codling as well. Of the skate, some were pretty large; one monster I measured was six feet across the pectorals and seven feet in length.

What struck me most was the absence of small fish. The flat fish were very large as a rule, and none were brought aboard even of the average size that we obtain in-shore. Unless in the case of codling, the destruction of small fish was practically *nil*.

The fish in the other places where we were getting a steady supply were evidently much more scattered, and the different classes of fish were much more equal in numbers. The food attraction was the reason of the inrush and concentration to this part. Some places are wonderfully constant in this respect. Although the fish

are being caught, the favourable conditions for feeding remain, and their places are taken by others from the surrounding grounds which are not fished or cannot be fished, and on which the fish may not be so numerous.

The question here again comes to be, if fishing is carried out in the places where fish abound on account of the relative abundance offered, and if few such places are left unfished in the North Sea, will these latter and the relatively less abundant places and the in-shore waters and the neighbouring oceans continue to supply and keep up the fishing grounds? There is a wide area to go and come upon, and it must not be under-estimated. The catch of fish increases every year, and still we find good catches can be made. Trawling, at least, is as successful as ever, if it is more difficult.

The other side of the question is that nearer the land and in protected waters, where there was relative abundance not so long ago, the fish have been much reduced in numbers, and this despite the closing of three miles from the shore to trawlers has not been recovered from. We have been able to show an improvement on this coast if we compare the last half of the period we have experimented in with the first. But, as a rule, such comparative trawling trials do not point to any change for the better. It is feared then that the history of those places near at hand will be repeated and intensified in those at a distance. Moreover, the one depends greatly on the other for its supply of fishes. From many of the spawning fish in the deeper waters the young of the in-shore areas are derived, where they are happily protected at least from one kind of fishing, and as these get mature they pass out to the deeper waters to feed and to spawn. In regard to plaice, statistics appear to show that over-fishing is already beginning to have an effect. More of them seem to be caught than are necessary to cope with the destructive agencies to which they are exposed. That is to say a sufficient number of them are not allowed to spawn, and in consequence the annual survival at all stages is reduced. Not only so, but "the worse you are, the worse you are likely to be." For enemies, finding that they cannot get a sufficiency of the larger forms, will be obliged to look further down the scale of size, and thus destruction will be intensified. It is quite clear that over-fishing must lead to a redistribution of food and feeding.

That the danger of over-fishing is recognised by people who ought to know is sufficiently well seen in the establishment of

hatcheries. It is evidently a confession to that effect, else they have no excuse for existence. But the little they can do is I fear totally out of proportion to the immense area which has to be supplied. It will have to be combined with some action which will reduce in some degree the immense destruction of fish, spawning or about to spawn, in the early months of the year.

We can afford to wait to see what statistics have to say in the next few years, and what experiments such as we are conducting disclose. The danger is, perhaps, not an immediate one, and as soon as it is imminent the remedy will be found.

ON THE HATCHING OF THE WASTE OVA OF THE MARKETS.

In the early part of this year we endeavoured to test an interesting point in the problem of fish-hatching, viz.—how far is it possible to utilize the ripe fish which are brought into the market for hatching purposes?

Mr. Storey had some difficulty in getting the fish that we required, and I can only report on two trials. They refer to cod spawn. In the first case the ovaries were simply torn up from evidently a fish which was not quite ripe, and besides had been dead for perhaps a day. Though mixed with milt from a male fish it was not surprising to find that fertilization had not been effected. The ova did not stir from the bottom.

The second lot was more successful. The ova were stripped from a ripe and living or recently dead cod, and successfully fertilized on the 9th April. The floating ova were afterwards seen to be going on all right. Many of them died, but a few were successfully hatched, and considering the meagre supply of water we had reason to be thankful.

I should be very glad in the coming season to make fresh trials with living fish, and fish which have been dead for a short period. Hatching, as you now know, is becoming a question of great importance. We have two hatcheries in this country. The ova for hatching are usually obtained from adult fishes, which are caught and retained in spawning ponds until they are ripe. Millions of little fry are thus obtained, and hatched and returned to the sea every year, to be added to the already large number contributed by the ordinary processes. It would not require very many fish after all to supply in nature the ova and fry furnished by even all the hatcheries already established. And it requires a great many more fish to produce this quantity of eggs in confinement than it does in a condition of nature. It is hoped to keep such fish in the ponds from year to year, but in obtaining them we actually join in what is causing the deterioration of the fisheries, and it is reasonable to suppose that a fair proportion of them if they had been left in the sea would have survived to have propagated their species even more

than once. Moreover, fish in the egg condition are as safe as fish can be from enemies. The fry which are poured back into the sea after being hatched artificially are just acquiring the colour and movements which make them objects of attraction to many an enemy. In the hatchery we preserve them during a time they do not require it, and launch them into the sea at a time that they do.

If this manner of hatching is open to criticism,—and we are not in a position yet to say much for it or against it,—still more so is the method of catching the fish, stripping them, fertilizing the ova, and sending them often a considerable distance to a hatchery. The fish in the first place could have managed the business better where they were, if they had been allowed to do so, and in the second place where is the sense in retaining the fertilized ova and sending them to a hatchery when the very best hatchery possible is just over the side of the boat, and that is where the fertilized ova should be poured in such an instance.

From my experience of life on board a trawler I am quite convinced that it is hopeless to think for a moment of the skipper or other men doing this, however much they may be assured that it would be to their ultimate benefit. They are on the fishing ground for one purpose only, and that is to catch fish. They do not concern themselves, nor indeed have they the time to concern themselves, about the years to come, nor even the next voyage for that matter. The same might be said of his less fortunate brother the line fisherman.

I have thought then that if only a proportion of the ova that are wasted every spawning season could be saved when it reaches the market that a hatchery devoted to this work would be a very useful institution. There are some considerations to be taken into account, however, before it can be seriously advised.

(1) Could a sufficiency of ova be obtained to make it worth while? I think the answer to that might easily be—yes. But (2) must the fish be absolutely living to prevent a great mortality? This is the question I want particularly to give a definite answer to. It has been shown in America that fish kept too long in the net,—that is for a day or two, and are therefore mostly dead,—give ova which do not develope satisfactorily. And it is to be feared that we may find the limits too exacting for the purpose we have in view. I am hopeful, however, if it were once established, that fresh fish brought into market may be stripped and the ova converted into living fish again, and if an

officer were appointed at each important port during the spawning season to receive these, that fishermen would facilitate the work by saving such fish as would be useful for the purpose.

It would not be necessary, of course, if responsible men were appointed to visit the important fishing grounds during the spawning months and strip the ripe fish, artificially fertilize the eggs, and return the products to the sea. It is a plan which, if carried out even by one boat, would soon place more ova in the sea in a season than all the hatcheries in the world. But the worst of it is you don't see the results in a tangible form as you do when you keep them in a hatchery and actually place them in the sea.

The hatching of waste ova (or embryos in this case) has evidently given good results in Newfoundland in the case of the lobster. As is well known, the great tinning factories send the embryos stripped from the tails of the lobsters to hatcheries, where they are kept until they are hatched, and then returned in suitable places to the sea. This could just as easily be done here, but if the recent bye-law of the Committee be carried into effect, the female lobsters ought to receive an efficient protection during the months of and preceding hatching and spawning.

In this connection it would be advisable to gather, through your fishery officers, statistics of the proportion of male and female lobsters and crabs. I am confident that figures of this kind, obtained also from Mr. Douglas, Beadnell, would be reliable and of much importance.

ON THE CRAB.

I received on the 3rd January of this year, from Mr. John Douglas, Beadnell, a female crab which throws some fresh light on the habits and life history of that species. Mr. Douglas furnished me with the following particulars regarding it. He found the male and female together in July, and keeping them under regular observation, he noted that the female cast her shell on the 12th August. He removed the male on the 17th August (after they had been together five weeks) and retained the female until it was placed in my hands on the date given above. He was good enough to send the cast shell as well. This was found to measure $5\frac{1}{4}$ inches. The crab measured $6\frac{5}{8}$ inches, and thus the animal gained at this casting $1\frac{3}{8}$ inches, or about one fourth in size. The shell was not completely hardened until the end of December, and thus four to five months are necessary for this process.

Unfortunately, during the early months of the year our supply of water was not constant, and on the 17th June I was greatly disappointed to find the tank empty and the crab dead. This was the more aggravating because the same cause had cut off the lobster previously received from Mr. Douglas. But I can assure him and others who may be good enough to send such interesting specimens that arrangements are now made which should preclude such risks.

Up to the time of the crab's death, which must have occurred about the 10th June, no eggs had appeared on the tail, and on opening the animal it was found that the ovaries were not at all in a ripe condition.

We know from the evidence which was gathered together for the Committee by Dr. Gregg Wilson that spawning occurs on this coast during the months of November, December and January. This I am able to confirm from observation and enquiries, at least for the two former months. The crab under consideration must have hatched out her embryos about the end of June or the beginning of July, and thus the incubation period is not less than six months. Her shell was cast on the 12th August, and it took until nearly the end of the year for the new shell to become fully matured. This fact, and the condition of the ovaries in June, showed that she

would not be in a position to spawn until at least the following November to January. We can therefore say that it is more than likely that the adult female crab casts and hatches in alternate years.

The period of casting given above agrees with the observations made by fishermen along the coast. The small crabs cast first, and during the latter part of August, and especially in September, the great majority are soft. During the winter months then, an immense number of the crabs which are caught are casters. The minority, less than 20 %, includes evidently females which have not yet spawned or those which have just become hard. The "berried hens" avoid the pots.

With regard to the proportion of the sexes caught at different seasons I have again to thank Mr. Douglas, Beadnell, for the following reply to an enquiry I sent him. There is a majority of male crabs early in the year, but "this majority is small, and continues so up to the end of April; in July and August the majority of females is very great, and this is the case until the end of September, when the male leaves the female."

Fishing for crabs during the winter months is, without doubt, very destructive. Mr. Douglas says that he traces the falling off in the crab fishery of the district to the time (about 1870) when the fishermen commenced to fish during the winter. As may be seen from the operations of the fishermen, the crabs go into deeper water during these months for protection, and return again in the spring. To give actual figures, I quote again from Mr. Douglas. "In October the usual depth is about 18 fathoms; if fishing were carried on during November and December, the depth would be about 26 fathoms. Fishing in February would be in about 18 fathoms, and in July from 6 to 10 fathoms. In the case of a mild winter the migration shorewards commences earlier."

For the most part, then, crabs remain within the limits, and should not therefore be liable to much destruction from the trawler. It is during the winter that the fishermen complain of a great deal of poaching, and if this occurs to the extent stated there is little doubt it will be a factor in destruction. Severe storms must be considered likewise as contributing to some extent to the number of losses. But the ordinary fishing, when carried on during this period, must be far more destructive than either of these. The statistics which have been gathered at various times by the Com-

mittee show that the soft crabs taken during these months are from 80 to 85 % of the catch, and as it is well known that these can scarcely be handled without causing fatal injuries, and especially if the thumb test be used to distinguish them from the saleable ones, and as, moreover, the catch is often drafted out after the boats have been brought to land, it would much benefit this class of fishery, and be no great hardship, to institute a close time, such as is given in the Committee's Bye-Laws now under consideration.

THE MARINE LABORATORY.

The work of collecting and arranging has been going on satisfactorily. Mr. G. P. Bulman has been arranging and tabulating our collections of mollusca, and his results are being overlooked by Mr. Howes, of the Hancock Museum. A preliminary report embodying their results will soon be ready. Mr. Spence worked in the laboratory for a month in the summer, devoting himself particularly to Polyzoa, of which he has made for the laboratory a collection and prepared a list, which, however, is to be reserved for a subsequent report.

Miss K. A. Smith, a student of the College, made use of the laboratory during the spring for general work. Dr. W. G. Smith, of the Yorkshire College, Leeds, spent a week at Easter studying marine Algæ.

But, as I have pointed out before, the laboratory must be fitted with certain very necessary articles before we can invite workers particularly from a distance. And knowing the wants and shortcomings, I have had actually to put off some applications which have been sent me.

A young fisherman should be appointed who would devote a few hours a day to collecting, to making and mending nets, and keeping the place tidy. If we had a boat, he could make regular excursions in the bay with the tow nets and with the dredge, and thus add materially to our collections and materials for study. Because of the want of means of storage, I have taken to the college some of the large specimens, where, indeed, a fishery collection would be of great value.

General View of the Mussel Bed near to the stream at Budle Bay. This part is exposed some four hours each tide. The stream may be seen in the background.

The Process of Screening. The space between the bars average $\frac{5}{8}$", which just stops mussels of 2" and upwards.

ON MUSSEL CULTURE ON THE COAST OF NORTHUMBERLAND.

As the only place where any attempt at mussel cultivation is made on this coast is at Budle Bay, my remarks will in the main be descriptive of the work which is being carried on there. I was enabled last summer to visit the beds which have been laid down by Major Browne, of Callaly Castle, and through the kindness of Mr. William King, who directs the mussel farm, I saw a great deal and learned much in regard to the experiences and observations furnished during the eight years of their existence. Mr. John Dent made a similar effort to stock beds on the Blyth, but the improvidence of the fishermen brought his experiment to an untimely and unfortunate conclusion.

The bait of the district, beside that which is got from Budle Bay, and the small quantities which can be gathered from places where it grows naturally to a useful size, is obtained from the Tees, Boston, Newhaven, Port Glasgow, Ireland, and Harlingen. Cullercoats, when all the cobles are engaged, requires about thirty cwts. per day, or say nine tons per week; and if we only assume a fishing season of twenty-four weeks, this gives a total of over 200 tons for the year. The other villages of the southern half of the district would require between them about 600 tons. And thus, for the whole district, at a low computation, we should say that 1,500 tons are needed.

At present the whole of this, except about 200 tons supplied from Budle Bay, is got from a distance, and it therefore behoves us to ask if it would not be possible to increase the home supply.

The mussel *(Mytilus edulis)* occurs naturally very commonly along the coast, but it is only in certain favourable situations that it grows to a bait size. These places are necessarily at the mouths of rivers and other sheltered situations where a plentiful supply of food occurs. Many of these places could easily be improved, and one or two might be made into very useful mussel farms. But one has in the first instance to deal with the fishermen. Our friends along the coast do not believe in saving any of the mussels to provide "seed" for future years. They are firm believers in spontaneous

generation in spite of all the experiences they have had which might lead at least to them suspecting the contrary. And yet these are just the men who cried out so earnestly some years ago about inshore trawling, and do so still. Should the attempt of Major Browne to establish a mussel farm at Budle Bay be copied at other parts of the coast, it is essential that the fishermen should be warned off, as Major Browne had to do; and that the bait should be supplied to them at some rate to be settled by the supply. Those who work the beds will only then be in a position to preserve portions for providing seed. The fishermen would, I am sure, soon begin to see the advantage of getting bait cheaply and easily and with their own boats, if the beds were sufficiently numerous, however much they might grumble at first at not being allowed to do as they like with all that lies in the sea.

Like other bivalves, the mussel tends to be sedentary, though it can move about and even climb, slowly of course, when it feels that it might improve its position. The sedentary condition is intensified by the byssus threads which are secreted by the foot. These anchor the mussel very firmly to the objects beside it. It does not, therefore, pursue its food. This must be brought to it suspended in the water in which it lives. It can be shown that a current is constantly passing into and out of the mussel when submerged and undisturbed. The water passes through the gills or along the alimentary canal, and so oxygen and food are carried into the animal. The food consists of vegetable debris, diatoms and other algæ.

One factor of much importance for the well-being of mussels is an adequate supply of food. This may be easily seen at Budle Bay. The stream-fed mussels, that is to say the mussels which are constantly under water, grow faster than those which can feed only during half a tide. The mussel in fact is liable to considerable modification, according to the conditions to which it is exposed. In sheltered places, and when constantly under water, the shell is thin, and the colour is a beautiful shade of green, as a rule, striped with darker lines. In more exposed situations a thicker, coarser shell is developed, having a more or less uniform brown or dark-blue colour.

The form as well as the colour and the size are liable to variation. When crowded together the mussels do not develop so fast as when they have more room. They tend, moreover, to have a rounded form. When they are planted in small clusters, or grown

in a suspended position, as on the wall of the oyster pond at Budle Bay, they grow faster and attain a comparatively large flattened appearance.

So distinct in short is the variation that with a little experience one can tell under what conditions the mussel has been grown, and fishermen can often tell you exactly where the mussel you show them came from

The sexes occur in separate animals, and they attain maturity at about a year old. The ripe condition is attained on the coast of Lancashire from May to July. Mr. King says that the lodgments of spat as a rule occur in August, reaches a maximum in September, and finishes early in October.

In France, the mussel spat "begins to settle on the posts in the end of spring and begining of summer."* Before the spat attach themselves they lead a free-swimming life for a short time, and during this period they may be carried by currents to a distance. Fullarton pointed out, in reporting on the Montrose mussel beds, that the larvæ may be lost by being carried away during heavy rains, or by being silted up with mud. A large number are also lost —lost so far as the beds are concerned—at the mouth of a river by being carried out to sea. It naturally follows that on suitable ground the greatest deposits will occur at places where the stream has slowed down.

At Budle Bay, as at some other mussel farms, some difficulty has been experienced in encouraging the lodgment of spat. There are certain small spots which, if kept free from weeds, appear to catch spat every year, while other parts of the ground, not differing in appearance from these, may be barren for years. The best ground consists of fine gravel with an admixture of clay, and having a gentle slope towards the side of the stream. The spat mostly lodges at a level where the tide runs over the ground only from two to four hours or even less. As we should expect, however, when a deposit occurs at about the two hours' level, the "seed" grows to about one inch long, and then dies from want of food. At the four hours' level the mussel developes to about two inches, and then dies for the same reason, though a cluster here and there may reach bait size, and fill fairly well.

We can gather from these observations that at Budle Bay, and many other places as well, a great quantity of larvæ is swept out to

* 1891. Fullarton.—Ninth Annual Report, Scottish Fishery Board.

sea by the stream, and it is only where the current is checked that a general deposit is possible. This occurs on the higher portions of the ground, and in the lower portions at places where eddies occur in the stream. The favourable conditions might well be extended by altering the bed of the stream so as to make it take a sinuous course. Post and wattles and walls, if so built as to cause eddies and check the current, in the more likely places, would, I am sure, still further give the larvæ a chance of spinning their byssus anchorage,

It has been pointed out that the mussel does not thrive in situations where it can only feed during a few hours every day. It is therefore necessary to remove the seed to a better feeding ground when it has reached a length of $\frac{1}{2}$-inch to $\frac{3}{4}$-inch. Fullarton says that mussels should at least measure $\frac{3}{4}$-inch before being lifted. The majority should be of that size at any rate. In another paper, the same authority says that in France "by autumn of the same year they were deposited," the mussels "have attained the size of haricot beans, when they are fit to be removed to the higher bouchots." At Budle Bay, at the time of lifting, the mussels are at least eighteen months old—say eighteen to twenty-four months. It must be remembered, of course, when considering this disparity that for one thing, with the French system, the spat is under water practically constantly during this initial period of growth, whereas the great majority of these we are now considering can only feed for from two to four hours during each tide.

In fact the bouchot system and that we are now describing are exactly opposite. In France the mussels are gradually removed from the outer to the inner bouchots, so that they get less and less feeding the older they get. Here the mussels get the least chance of feeding in their young condition, and are changed to more and more suitable ground for feeding until they are finally fattened in the stream.

The temperature at Budle Bay, moreover, varies a good deal, and during the summer there must be many a day during which the exposed mussels must get a roasting. The water also as it comes lapping over the warm sand will be very warm at first, and will gradually get colder and colder as the tide advances. Such mussels and spat as are exposed for many hours every day will thus have to cope with a considerable variation in temperature. Their conditions

would be less severe in that respect, and they would grow much faster if they could be kept for a longer time under water.

In the oyster pond at Budle Bay the temperature averages 33° F. in winter, and 57° to 66° F. is obtained in the summer.

The mussels get a final change to the stream when they have attained a size of one-and-a-half to two inches, and after a year of the constant feeding their position now gives them, they are ready to be sold to the fishermen.

Under the treatment which I have sketched out, it takes some 5—6 years for a mussel to reach bait size when planted fairly thickly. If planted in smaller clusters only four years are required, viz.—

18 months before removal.
18 ,, growth.
12 ,, fattening in the stream.

The best results under present conditions at Budle Bay are obtained by giving the growing mussels 6—7 hours' submergence each tide. With less than that the mussels may grow to nearly the same size, but they do not fill properly. Still better results would naturally follow a longer period of feeding.

There is plenty of food in the bay for mussels: all that is wanted is to put the mussels under water that they may feed upon it. A trial pond was made at the four hours' level in which the mussels were always under twelve to eighteen inches of water, which, of course, was renewed every tide. The mussels which were planted for a full crop grew to a good bait size and fattened seemingly as well as those under water for seven hours in the tide. Owing to its high level, however, the pond became a deposit for weed, which unfitted it for cultivation.

Of course, as has already been pointed out, even in the best situations, planting in small clusters favours growth and fattening, while planting to produce say sixty to one hundred tons per acre retards development: the mussels attain a round shape, and are not so well filled. I need scarcely mention, moreover, that spates if continued do not favour the development and fattening of mussels.

At Budle Bay the native mussel was taken and a beginning made with the few that, with much difficulty, could be collected. These were brought together, and the ground near them cleared to encourage the lodgment of spat. This was in 1890. In the fishing

season of 1896-7, one hundred tons of bait mussel were sold, and this season the sales will be about double that of last.

I need only remark in conclusion that there are other Northumberland streams and rivers which are daily carrying down vegetable matter such as diatoms and algæ to the sea, and that much of that could be trapped before it quite reached that length, or immediately it got there, and converted into bait for the fishermen. I should like very much to see this Committee empowered to lay down beds, and to see to their maintenance, in many places where mussels are found to grow naturally to a useful size.

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